Volume 63 Article 3

1-1-1976

Sensing Iowa's Natural Resources Via Satellite

Richard E. Carlson
Iowa State University

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The management of natural resources and the use of these same resources in Iowa is a growing concern. Various methods such as statistical sampling and analysis of aerial photographs are used to monitor and inventory these resources. This report discusses the use of orbiting satellite sensing platforms to achieve these objectives.

Description of ERTS and Skylab Platforms

On July 23, 1972 the first unmanned Earth Resources Technology Satellite (initially called ERTS-1, but now named LANDSAT-1) was launched into a polar orbit circling 920 kilometers above the surface of the earth. LANDSAT completes each orbit in 103 minutes, approximately 14 orbits/day. Thus, LANDSAT is capable of viewing the entire earth every 18 days by advancing westward with each successive orbit.

The instrument package aboard LANDSAT is a multi-spectral scanner (MSS) which records energy reflected from the earth's surface in 4 wavelength regions. Two bands sense the visible spectrum and the others detect near-infrared (not thermal) reflected energy. The multi-spectral scanner is not to be confused with standard camera-film-filter systems. Reflected energy is collected via the scanner and these electronic signals are then transmitted to a receiving station on earth.

At the receiving station, or at a NASA data facility, these data are then processed into various products. The most commonly used product is the 70 mm transparency. An example of a black and white print from a near-infrared transparency for one entire scene in central Iowa is presented in Figure 1. The data were collected on May 10, 1973. The scene is approximately 185 km x 185 km.

NASA has also utilized manned spacecraft for earth resources studies. The most famous was Skylab, which orbited approximately 430 kilometers above the earth's surface. The sensor systems aboard this craft included both multispectral scanners and sophisticated camera systems which the astronauts operated directly. An example of a photographic product acquired over Iowa during Skylab-3 is shown in Figure 2.

General Methods of Analysis

Many, many methods are available to extract information from a photograph. Some are very simple, other very complex, and some are used strictly for specific applications. I will discuss only the methods used in this research relating to soils,

1. This research was partly supported by NASA contract # NAS5-21739, National Aeronautics and Space Administration and the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa. Project 1997.

The Author—Richard E. Carlson is presently an Associate Professor of Agricultural Climatology, Department of Agronomy, Iowa State University, Ames, Iowa. He received his B.S. from the University of Nebraska, and his M.S. and Ph.D. from Iowa State in 1969 and 1971 respectively. His research interests are in agricultural climatology and remote sensing.

crops, and forestry applications using LANDSAT data.

The LANDSAT sensor was a multi-spectral scanner designed to record reflected energy in four spectral regions. This is an important point because objects and features on the surface differentially reflect solar radiation resulting in a "finger print" or a "spectral signature". If one is interested in separation or identification of surface features, these signatures must be different. To illustrate this point an example is given in Figure 3 where enlargements from August images representing both visible and near-infrared bands are presented.

Even though these two images were collected at exactly the same time, different features are highlighted depending upon the wavelength sensitivity of the scanner. The visible band, Figure 3A, details towns, roads, and stubble fields. Very little separation exists for crops, forest cover, or bodies of water in this photo. In contrast, the near-infrared band, Figure 3B, highlights bodies of water and some crops, but towns and roads are not distinguishable. At this particular time the other visible band was not distinctive for any feature and the remaining near-infrared image was very similar to Figure 3B.

Another important feature of the LANDSAT system is repetitive or temporal coverage. This may be critical for some separations or identifications because features of interest may look different only at one time or only for a short period of time. Compare Figure 1 and Figure 3B for an illustration of this point. Both photos were produced from the same sensor band, near-infrared, but they look quite different. The May image highlights early season vegetation whereas the August image details other crop types and land features. As can be seen from these examples both temporal and multi-spectral coverage can be very important for information extraction. A last example is given in Figure 4. This image includes the same area represented in Figure 3, but this image was generated during January when the surface was covered with snow. The forest cover is quite marked along the Des Moines, Skunk, and Squaw drainage systems. In other portions of this image, topographic features were evident.

Extracting the Desired Information

If the reduced resolution of the high-flying LANDSAT data collection system is acceptable when compared to high resolution low flyers, how can useful information be readily extracted? There are two general methods, visual-manual processing and computer-assisted processing.

Figure 1. MSS ERTS-1 coverage of central and west-central Iowa during May, 1973. Dark areas are mostly actively growing vegetation, towns, and some roads. Grey and light areas correspond to fields at various stages of early season tillage. White areas indicate water, lakes, and rivers.

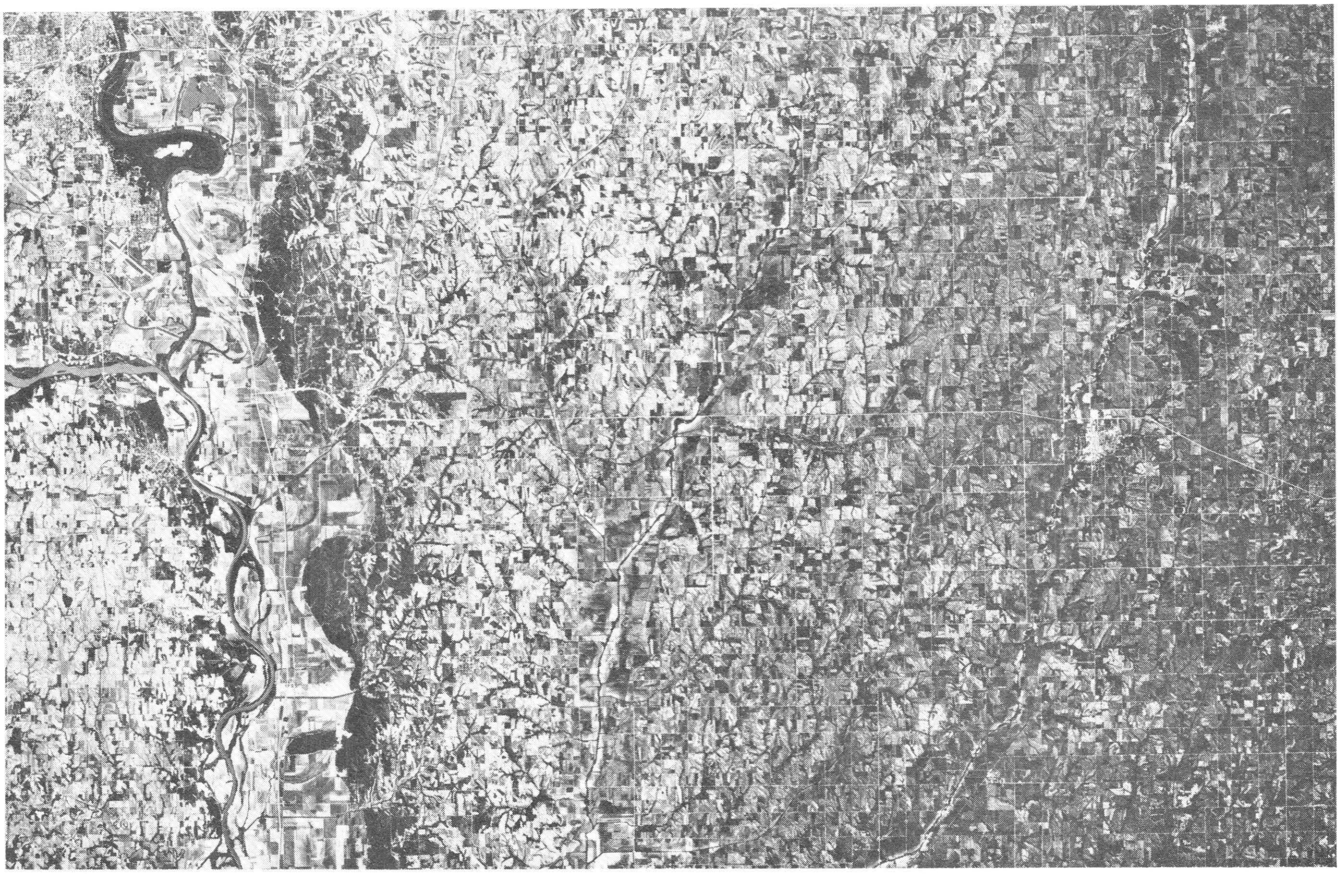


Figure 2. A portion of a Skylab image, S190B camera system, covering western Iowa during June, 1973.

The visual-manual processing methods are detailed in classroom texts, but one feature applicable to the multi-spectral LANDSAT system may be of interest. This method is called additive color processing. Basically, multi-spectral transparencies are registered and different colors are projected through each transparency onto the same screen. This is a false-color process resulting in an image which does not appear as our eyes would perceive the scene. Unfortunately, an example cannot be presented here, but to illustrate, when blue, green, and red lights are applied to scanner bands 4, 5 and 7, respectively, a color infrared rendition results. This particular example produces an image which accentuates vegetation. Color infrared film is frequently used in vegetation inventory and plant disease studies because vegetation is generally highly reflective to near-infrared solar radiation.

Additive color processing is generally applied to multi-spectral transparencies collected at the same time, though we have successfully registered and used temporal and multi-spectral transparencies. These images are very striking to the eye because the colors produced are much different than normal, and can be very useful for separation of surface features.

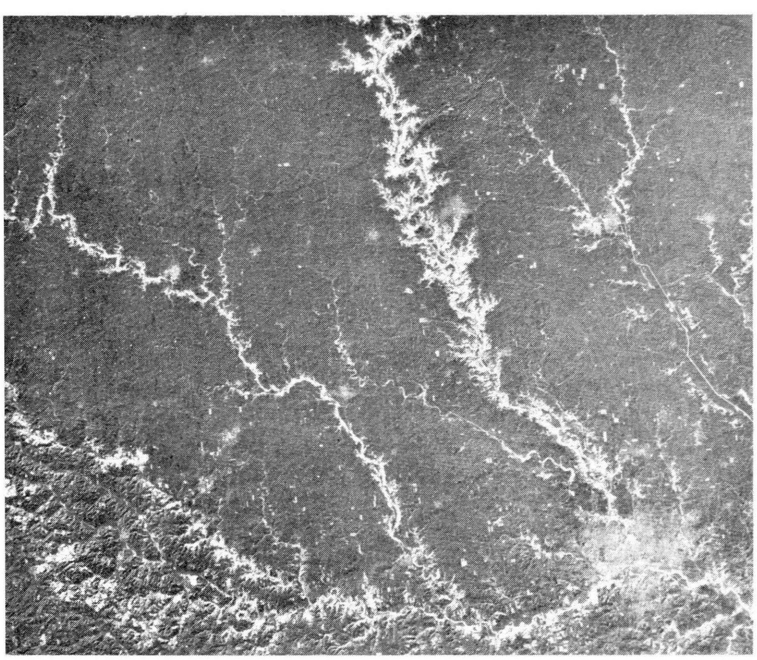
To illustrate the second information extraction method, computer-assisted processing, let us assume that it is necessary to determine the amount of forested land in central Iowa. From Figure 4 (near-infrared image) forested land appears different than most other land uses at that time. Visual-manual techniques would be very time-consuming and tedious for any photo-interpreter. Computer compatible tapes (CCT's) could therefore be used to conduct the study because the digital data stored on the CCT's would be directly comparable to the gray levels observed in Figure 4. A word of caution is necessary at this point. In order to use the CCT's and the computer, an area must be selected and used to "train" the computer to recognize the desired features as represented by the digital data contained on the CCT's. This area, called "ground truth", is a very important part of this hypothetical study. It forms the link between known forested areas present in the scene with those forested sites never visited by an interpreter. After this link is formed, the computer could easily scan the data tapes and produce the desired forest land inventory.

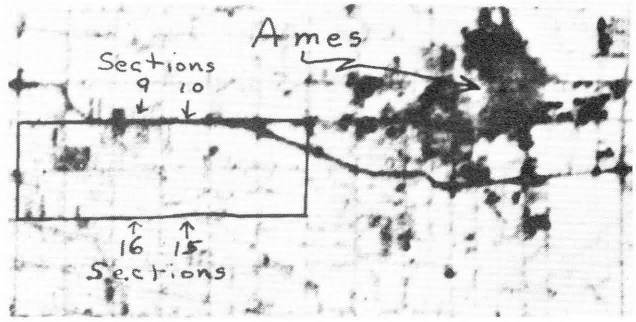
Before we let the computer do all the work, one point should be noted. We assumed that all areas in the image, which appeared like the ground truth area, are forest land. This may not be true in all cases. A close examination of Figure 4 reveals other small, white areas which are not forested land. Some lighter areas correspond to towns and others were unpicked corn fields resulting from a very wet fall season. This example serves as a reminder that computer-assisted and human interpretations should be closely linked to obtain the best possible interpretation attainable.

This forest inventory example is relatively simple and straightforward using only one image and two classifications, forested versus non-forested land. Other examples are usually more complex and many temporal, multi-spectral images may be required to attain a complete separation and identification of all surface features.

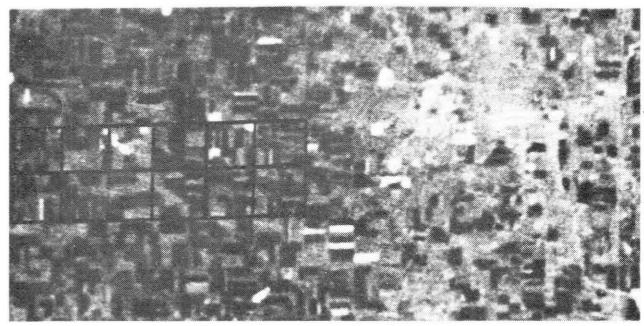
To illustrate, consider the problem of completing an inventory of cropland by types for central Iowa. An examination of Figures 1-4 reveals that many separations exist and, therefore, computer-assisted interpretation appears to be a possibility. As usual, a ground truth area must be established and examined closely so that comparisons between ground truth and available satellite images can be studied, but other problems relating to temporal analysis develop. The problems which develop are two-fold. First, temporal analysis via CCT's requires that the images (or digital data) must be registered or superimposed. This is being done, but the registration is difficult and never exact. Secondly, cloud cover can produce very serious limitations. The LANDSAT platform views the same area once every 18 days, but if clouds are present during a fly-by, no surface features can be observed. Required temporal separations may not be achieved. In our experiments in Iowa, a test site in western Iowa was viewed by LANDSAT 11 times in 1973; whereas, the test site in eastern Iowa was viewed only 3 times during the same time period. This limited coverage in eastern Iowa precluded temporal analysis for that area.

Figure 4. An MSS ERTS-1 coverage of snow-covered central Iowa during January, 1973. Forested lands and towns are highlighted.





A. Visible band highlighting towns, roads, and stubble fields.



B. Near infrared band highlighting crops and bodies of water.

Figure 3. MSS ERTS-1 coverage of Ames, Iowa during August, 1973.

Although the orbiting altitude of LANDSAT places restrictions on the resolution of surface features, the broad synoptic makeup of large areas is revealed. A mosaic of Iowa was produced from early season near-infrared images. This composite is quite dramatic and shows general soil and land-use patterns. Other mosaics of the state, which depict other seasons, reveal general crop and forest land state wide patterns. In the case of Iowa, this type of information, although not current in all cases, is usually known via previous sampling or aerial photograph acquisition. But, in some foreign countries and in areas in the United States where topography or vegetation restricts the ground sampling surveys, this information is not readily available.

Consequently, LANDSAT is providing a unique and useful source of information in many areas of interest including forestry, agriculture, geology, and hydrology to name a few. Earth resource sensing via satellite data acquisition systems is a new, rapidly-expanding science created by man's technology and man's interest in his environment and natural resources.